What is claimed is:

1. In a hearing amplification device adapted to receive a sound signal, the hearing amplification device having at least one channel configured to receive an input representative of said sound signal, the improvement comprising:

said channel being further configured to provide (1) linear gain for an input representative of a portion of said sound signal having a sound level less than a compression threshold, (2) rapid compressive gain for an input representative of a portion of said sound signal having a sound level greater than said compression threshold, wherein said rapid compressive gain is less than said linear gain, and (3) adaptive control of said compression threshold.

2. The hearing amplification device of claim 1 wherein said at least one channel is further configured to provide said rapid compressive gain as instantaneous compressive gain.

3. The hearing amplification device of claim 2 wherein said at least one channel is further configured to adjust said compression threshold at least partially in response to changes in said sound signal.

SUB A12

~~4. The hearing amplification device of claim 3 wherein said at least one channel is configured to have its compression threshold initially set to a predetermined quiescent level, and wherein said at least channel is further configured to adjust said compression threshold such that said compression threshold is in a range of about said predetermined quiescent level to about 20 decibels below an~~

average sound level of at least a portion of said sound signal.

5. The hearing amplification device of claim 3 wherein said at least one channel is configured to adjust said compression threshold such that said compression threshold is within a range of about 5 decibels below an average sound level of at least a portion of said sound signal to about 5 decibels above said average sound level.

6. The hearing amplification device of claim 3 wherein said at least one channel is further configured to provide a smooth transition between said linear gain and said instantaneous compressive gain.

7. The hearing amplification device of claim 3 wherein said at least one channel is further configured to provide a sharp transition between said linear gain and said instantaneous compressive gain.

8. The hearing amplification device of claim 3 wherein said at least one channel is further configured to provide (1) constant gain for an input representative of a portion of said sound signal having a sound level greater than a decompression threshold, said decompression threshold being greater than said compression threshold, said constant gain being less than said compressive gain and (2) said instantaneous compressive gain which converges to said constant gain for increasing sound levels.

9. The hearing amplification device of claim 8 wherein said at least one channel is configured to have its compression threshold initially set to a predetermined quiescent level, and wherein said at least one channel is

further configured to adjust said compression threshold such that said compression threshold is in a range of about said predetermined quiescent level to about said decompression threshold.

10. The hearing amplification device of claim 8 wherein said at least one channel is further configured to provide attenuation for an input representative of a portion of said sound signal having a sound level greater than an attenuation threshold, said attenuation threshold being greater than said decompression threshold.

11. The hearing amplification device of claim 2 wherein said at least one channel is further configured to provide said instantaneous compressive gain as at least square root compression.

12. The hearing amplification device of claim 2 wherein said at least one channel is further configured to adjust said compression threshold at least partially in response to a user input.

13. The hearing amplification device of claim 2 having a plurality of said channels, each of said channels being responsive to an input representative of an audio frequency range different from other channels.

14. The hearing amplification device of claim 13 wherein each channel is configured to have its compression threshold initially set independently of each other channel, and wherein each channel is further configured to adjust its compression threshold at least partially in response to changes in said sound signal.

15. The hearing amplification device of claim 14 wherein each channel is configured to independently adjust its compression threshold at least partially in response to changes in said sound signal.

16. The hearing amplification device of claim 14 wherein each channel is further configured to provide (1) constant gain for an input representative of a portion of said sound signal having a sound level greater than a decompression threshold, said decompression threshold being greater than said compression threshold, said constant gain being less than said compressive gain, and (2) instantaneous compressive gain which converges to said constant gain for increasing sound levels.

17. The hearing amplification device of claim 16 wherein each channel is configured to have its compression threshold initially set to a predetermined quiescent level, and wherein each channel is further configured to adjust its compression threshold such that its compression threshold is in a range of about its predetermined quiescent level to about said decompression threshold.

18. The hearing amplification device of claim 17 wherein each channel is further configured to adjust its compression threshold such that its compression threshold is in a range of about said predetermined quiescent level to about 20 decibels below an average sound level of at least a portion of said sound signal.

19. The hearing amplification device of claim 17 wherein each channel is configured to adjust its compression threshold such that its compression threshold is within a

range of about 5 decibels below an average sound level of at least a portion of said sound signal to about 5 decibels above said average sound level.

20. A method of compensating for impaired hearing, said method comprising:

linearly amplifying an input corresponding to a portion of a sound signal having a sound level less than a compression threshold;

rapidly compressively amplifying an input corresponding to a portion of a sound signal having a sound level greater than said compression threshold, and

adaptively controlling said compression threshold at least partially in response to changes in said sound signal.

21. The method of claim 20 wherein said rapidly compressively amplifying step includes instantaneously compressively amplifying an input corresponding to a portion of a sound signal having a sound level greater than said compression threshold.

22. The method of claim 21 further comprising:

initially setting said compression threshold at a predetermined quiescent level;

storing a previously determined peak value for a previous portion of said sound signal;

determining a current peak value for a current portion of said sound signal; and

wherein said adaptively controlling step includes instantly increasing said compression threshold when said determined current peak value is greater than said stored peak value.

23. The method of claim 22 wherein said adaptively controlling step includes:

maintaining said compression threshold at its current level when said determined current peak value does not deviate by more than a predetermined triggering amount from said stored peak value; and

decreasing said compression threshold when said determined current peak value deviates by more than said predetermined triggering amount from said stored peak value.

24. The method of claim 23 wherein said decreasing step includes:

decreasing said compression threshold when said determined current peak value has continuously deviated by more than said predetermined triggering amount from said stored peak value for a predetermined amount of time.

25. The method of claim 24 wherein said adaptively controlling step further includes:

setting a maximum value for said compression threshold;

setting a minimum value for said compression threshold;

estimating an average sound level for at least a portion of said sound signal from said determined current peak value;

wherein said instantly adjusting step includes increasing said compression threshold to substantially match said estimated average sound level when said estimated average sound level is less than or equal to said maximum value and increasing said compression threshold to equal said maximum value when said estimated average sound level is greater than said maximum value; and

wherein said decreasing step includes decreasing said compression threshold by a fixed amount when said compression threshold minus said fixed amount would not be less than said minimum value and decreasing said compression threshold to equal said minimum value when said compression threshold minus said fixed amount would be less than said minimum value.

26. The method of claim 25 further comprising:

providing constant gain for an input corresponding to a portion of a sound signal having a sound level greater than a decompression threshold, wherein said decompression threshold is greater than said compression threshold, said constant gain being less than said compressive gain, and wherein said instantaneous compressive amplification converges to said constant gain for increasing sound levels.

27. The method of claim 26 wherein said step of setting said maximum value includes setting said maximum value as said decompression threshold, and wherein said step of setting said minimum value includes setting said minimum value as said predetermined quiescent level.

28. The method of claim 21 further comprising:

providing constant gain for an input corresponding to a portion of a sound signal having a sound level greater than a decompression threshold, wherein said decompression threshold is greater than said compression threshold, said constant gain being less than said compressive gain, and wherein said instantaneous compressive amplification converges to said constant gain for increasing sound levels.

29. The method of claim 28 further comprising:

attenuating an input corresponding to a portion of a sound signal having a sound level greater than an attenuation threshold, wherein said attenuation threshold is greater than said decompression threshold.

30. The method of claim 21 further comprising:

performing each of said steps for a plurality of different audio frequency ranges.

31. The method of claim 21 further comprising providing a smooth transition between said linear amplification and said instantaneous compressive amplification.

32. The method of claim 21 further comprising providing a sharp transition between said linear amplification and said instantaneous compressive amplification.

33. A nonlinear hearing amplification device adapted to receive and amplify a sound signal, said device comprising:

a transducer for processing a transducer input according to a transfer function to thereby produce a transducer output, said transducer input being representative of a sound signal, said transducer output being representative of an amplified sound signal, said transfer function being configured to provide (1) linear gain for a transducer input representative of a portion of said sound signal having a sound level less than a compression threshold, and (2) rapid compressive gain for a transducer input representative of a portion of said sound signal having a sound level greater than said compression threshold, wherein said rapid compressive gain is less than said linear gain; and

a compression threshold controller coupled to said transducer for adjusting said compression threshold at least partially in response to changes in said sound signal.

34. The device of claim 33 wherein said transfer function is configured to obey odd symmetry.

35. The device of claim 33 wherein said transducer is memoryless to provide said rapid compressive gain instantaneously.

36. The device of claim 35 wherein said compression threshold is initially set to a predetermined quiescent level, and wherein said controller is configured to:

estimate an average sound level for at least a portion of said sound signal; and

adjust said compression threshold in a range of about said predetermined quiescent level to about 20 decibels below said estimated average sound level.

37. The device of claim 35 wherein said controller is configured to:

estimate an average sound level for at least a portion of said sound signal; and

adjust said compression threshold in a range of about 5 decibels below said estimated average sound level to about 5 decibels above said estimated average sound level.

38. The device of claim 35 wherein said transfer function is further configured to provide a smooth transition between said linear gain and said instantaneous compressive gain.

39. The device of claim 35 wherein said transfer function is further configured to provide a sharp transition between said linear gain and said instantaneous compressive gain.

SUB A13

40. The device of claim 35 wherein an asymptotic representation of said transfer function TA1 is defined by the general formula:

$$TA=TA(u,A,U,p),$$

wherein for $|u| < U$:

$$TA(u,A,U,p) = Au$$

wherein for $|u| > U$

$$TA(u,A,U,p) = \operatorname{sgn}(u) AU \left|\frac{u}{U}\right|^{p}$$

wherein:

$$TA1=TA1(u,U_C)=TA(u,A(U_C),U_C(Y),p);$$

wherein $U_C(Y)= U_1$ for Y less than U_1 and $U_C(Y) = Y$ for Y greater than or equal to U_1, wherein U_1 represents a quiescent level for said compression threshold, wherein U_C represents an adjusted compression threshold, wherein Y represents a control signal from said controller for controlling said compression threshold, wherein u represents said transducer input, wherein p represents a compression power, and wherein A represents a magnitude of gain, wherein for Y less than U_1:

$$A = G_1$$

and wherein for Y greater than or equal to U_1:

$$A = G_1 \left|\frac{U_1}{U_C}\right|^{1-p}$$

wherein G_1 represents the magnitude of said linear gain.

41. The device of claim 35 wherein said transfer function is further configured to provide constant gain for a

transducer input representative of a portion of said sound signal having a sound level greater than a decompression threshold, wherein said decompression threshold is greater than said compression threshold, and wherein said constant gain is less than said compressive gain.

SUB A14

42. The device of claim 41 wherein an asymptotic representation of said transfer function is defined as a cascade of two functions TA1 and TA2, wherein both TA1 and TA2 are defined the general formula:

$$TA=TA(u,A,U,p),$$

wherein for $|u| < U$:

$$TA(u,A,U,p)=Au$$

wherein for $|u| > U$

$$TA(u,A,U,p)=\mathrm{sgn}(u)AU\left|\frac{u}{U}\right|^{p}$$

wherein:

$$TA1=TA1(u,U_C)=TA(u,A(U_C),U_C(Y),p);$$

wherein $U_C(Y)= U_1$ for Y less than U_1, $U_C(Y) = Y$ for Y greater than or equal to U_1 and less than or equal to U_2, and $U_C(Y)=U_2$ for Y greater than U_2, wherein U_1 represents a quiescent level for said compression threshold, wherein U_2 represents said decompression threshold, wherein U_C represents an adjusted compression threshold, wherein Y represents a control signal from said controller for controlling said compression threshold, wherein u represents said transducer input, wherein p represents a compression power, and wherein A represents a magnitude of gain, wherein for Y less than U_1:

$$A=G_1$$

and wherein for Y greater than or equal to U_1:

$$A=G_1\left|\frac{U_1}{U_C}\right|^{1-p}$$

Sub A14

wherein G_1 represents the magnitude of said linear gain; and

wherein for TA2=TA2(u)=TA(u,1,U_2,p_2), wherein u represents TA1, wherein U_2 represents said decompression threshold, and wherein p_2 represents 1/p_1.

43. The device of claim 41 wherein said transfer function is further configured to provide attenuation for a transducer input representative of a portion of said sound signal having a sound level greater than an attenuation threshold, wherein said attenuation threshold is greater than said decompression threshold.

Sub A15

44. The device of claim 43 wherein an asymptotic representation of said transfer function is defined as a cascade of three functions TA1, TA2, and TA3, wherein TA1 , TA2, and TA3 are each defined the general formula:

TA=TA(u,A,U,p),

wherein for |u| < U:

$$TA(u, A, U, p) = Au$$

wherein for |u| > U

$$TA(u, A, U, p) = \operatorname{sgn}(u) A U \left|\frac{u}{U}\right|^{p}$$

wherein:

TA1=TA1(u,U_C)=TA(u,A(U_C),U_C(Y),p_1);

wherein U_C(Y)= U_1 for Y less than U_1, U_C(Y) = Y for Y greater than or equal to U_1 and less than or equal to U_2, and U_C(Y)=U_2 for Y greater than U_2, wherein U_1 represents a quiescent level for said compression threshold, wherein U_2 represents said decompression threshold, wherein U_C represents an adjusted compression threshold, wherein Y represents a control signal from said controller for controlling said compression threshold, wherein u represents said transducer input, wherein p_1 represents a first

compression power, and wherein A represents a magnitude of gain, wherein for Y less than U_1:

$$A = G_1$$

and wherein for Y greater than or equal to U_1:

$$A = G_1 \left| \frac{U_1}{U_C} \right|^{1-p}$$

wherein G_1 represents the magnitude of said linear gain;

wherein for $TA2=TA2(u)=TA(u,1,U_2,p_2)$, wherein u represents TA1 or TA3, wherein U_2 represents said decompression threshold, and wherein p_2 represents $1/p_1$; and

wherein for $TA3=TA3(u)=TA(u,1,U_3,p_3)$, u represents TA1 or TA2, wherein U_3 represents said attenuation threshold, and wherein p_3 represents a second compression power.

SUB A5

45. The device of claim 35 further comprising a plurality of said transducers and a plurality of channels, each channel being responsive to a different predetermined channel frequency range and comprising one of said transducers, and wherein said controller is coupled to each of said transducers, wherein said transducer input for each transducer is representative of those frequency components of said sound signal that are within its corresponding predetermined channel frequency range.

46. The device of claim 45 wherein each of said channels and said controller are implemented in a digital signal processor, each transducer input being a digital representation of said sound signal.

47. The device of claim 46 wherein said digital signal processor is a multirate digital signal processor.

48. The device of claim 45 wherein each of said channels and said controller are implemented in a plurality of analog components.

49. The device of claim 35 wherein said transducer and said controller are implemented in a digital signal processor, said transducer input being a digital representation of said sound signal.

50. The device of claim 49 wherein said digital signal processor is a multirate digital signal processor.

51. The device of claim 35 wherein said transducer and said controller are implemented in a plurality of analog components.

52. The device of claim 35 wherein said controller is configured with:

a first operating mode in which said controller is configured to not adjust said compression threshold; and

a second operating mode in which said controller is configured to adjust said compression threshold at least partially in response to changes in said sound signal;

wherein said controller is switchable between said first operating mode and said second operating mode.

53. The device of claim 52 wherein said controller is further configured with:

a third operating mode in which said controller is configured to fix said compression threshold at a current level;

wherein said controller is switchable between said first operating mode, said second operating mode, and said third operating mode.

54. The device of claim 53 wherein said controller is configured to switch between said first operating mode, said second operating mode, and said third operating mode at least partially in response to a user input.

55. A hearing amplification device for producing an amplified sound signal from a received sound signal, said hearing amplification device comprising a digital signal processor configured to:

pass a first data set representative of said received sound signal through a transfer function to thereby create a second data set representative of said amplified sound signal, wherein said transfer function is configured to provide (1) linear gain for data representative of a sound signal having a sound level less than a compression threshold, (2) instantaneous compressive gain for data representative of a sound signal having a sound level greater than said compression threshold, wherein said instantaneous compressive gain is less than said linear gain; and

adjust said compression threshold at least partially in response to changes in said received sound signal.

56. A hearing amplification device comprising:

a transducer for producing a transducer output from a transducer input, said transducer input being representative of a sound signal, said transducer output being produced by processing said transducer input according to a transfer function, said transfer function being configured to provide (1) linear gain for a transducer input representative of a portion of said sound signal having a sound level less than a compression threshold, and (2) rapid compressive gain for a transducer input representative of a portion of said sound signal having a sound level greater than said compression

threshold, wherein said instantaneous compressive gain is less than said linear gain; and

a compression threshold controller coupled to said transducer and configured to switch said compression threshold between at least two values.

57. The hearing amplification device of claim 56 wherein said controller is configured to switch said compression threshold at least partially in response to changes in said sound signal.

58. The hearing amplification device of claim 56 wherein said controller is further configured to switch said compression threshold at least partially in response to a user input.

59. A method of diagnosing an extent and form of hearing impairment, said method comprising:

determining an amount of low level gain G_1 needed by a patient in a plurality of different audio frequency ranges for sound signals having a low sound level;

selecting a compression power p;

adjusting a hearing amplifier device having a plurality of channels corresponding said audio frequency ranges to provide the determined low level gain G_1 for each channel and selected compression power p, said hearing amplification device being configured to process an input signal representative of a sound signal according to a merging family of channel transducer characteristics to create an amplified signal, said characteristics defined by (1) linear gain for input signals representative of a sound signal having a sound level less than a compression threshold, (2) rapid compressive gain for input signals

representative of a sound signal having a sound level greater than a compression threshold;

presenting a sound signal at an input of the hearing amplification device to generate an amplified signal therefrom;

providing to the patient the amplified signal generated from said presented sound signal; and

adjusting the values of said compression threshold for low level gain G_1 for each channel and said compression power p until the patient communicates that he/she has perceived satisfactory results.

60. A hearing amplification device adapted to receive a sound signal, the hearing amplification device comprising:

at least one channel configured to receive an input representative of said sound signal, said at least one channel comprising an amplifier for (1) amplifying the input throughout a first range of sound levels and (2) compressively amplifying the input throughout a second range of sound levels, said sound level ranges having at least one end point defining at least one extreme value in its corresponding range, and

a compression threshold controller in circuit with said amplifier for adjusting the value of at least one sound level range end point.

61. The device of claim 60 wherein said sound level ranges are contiguous at a common end point, and wherein said compression threshold controller is configured to adjust the value of said common end point.

62. The device of claim 61 wherein said compression threshold controller is configured to adjust the value of

said common end point at least partially in response to changes in said input.

63. A hearing amplification device adapted to receive a sound signal, the hearing amplification device comprising:

at least one channel configured to receive an input representative of said sound signal, said channel comprising an amplifier for compressively amplifying said input throughout a range of sound level values, and

a controller in circuit with said amplifier for adjusting a beginning value of said range.

64. A hearing amplification device adapted to receive a sound signal, the hearing amplification device having at least one channel configured to receive an input representative of said sound signal, an IWDRC amplifier for amplifying said input, and a controller coupled to the amplifier for adjusting a threshold sound level value for compressive amplification of said input.

65. A hearing amplification device for producing an amplified sound signal from a received sound signal, said hearing amplification device comprising a analog signal processor configured to:

pass an analog signal representative of said received sound signal through a nonlinear amplifier to thereby create an amplified analog signal representative of said amplified sound signal, wherein said nonlinear amplifier is configured to provide (1) linear gain for data representative of a sound signal having a sound level less than a compression threshold, (2) instantaneous compressive gain for data representative of a sound signal having a sound level greater than said compression threshold, wherein said

instantaneous compressive gain is less than said linear gain; and

adjust said compression threshold at least partially in response to changes in said received sound signal.